

What is claimed is:

1. An attitude angle control apparatus which controls an attitude angle of a part of a marine vessel, comprising:
  - a measuring device for measuring the attitude angle of the part of the marine vessel and specific fuel consumption of the marine vessel or alternative values relating to the specific fuel consumption of the marine vessel;
  - 5 a statistical model generator for generating a statistical model based on data from the measuring device; and
  - an attitude angle controller for selecting an optimum attitude angle of the part 10 of the marine vessel based on the statistical model generated by the statistical model generator.
2. An attitude angle control apparatus according to claim 1, wherein the attitude angle controller controls the attitude angle of the part of the marine vessel 15 based on the optimum attitude angle.
3. An attitude angle control apparatus according to claim 1, wherein the attitude angle controller includes a target attitude angle calculator for calculating a target value of the attitude angle of the part of the marine vessel based on the specific 20 fuel consumption or the alternative values relating to the fuel consumption and based on the statistical model generated by the statistical model generator.
4. The attitude angle control apparatus according to claim 3, wherein the target attitude angle calculator calculates, based on the statistical model generated by 25 the statistical model generator, the attitude angle at which the specific fuel consumption reaches a maximum value, as the target value of the attitude angle.

5. The attitude angle control apparatus according to claim 3, wherein if a difference between the target value of the attitude angle calculated by the target attitude angle calculator and a current attitude angle exceeds a limit, the target attitude angle calculator sets the limit as the target value of the attitude angle.

5

6. An attitude angle control apparatus according to claim 1, wherein the part of the marine vessel is at least one of a hull and a propeller.

7. An attitude angle control apparatus according to claim 6, wherein the  
10 attitude angle controller controls an angle of the propeller with respect to the hull.

8. The attitude angle control apparatus according to claim 1, wherein the alternative values relating to the specific fuel consumption include at least one of actual total fuel consumption, engine speed, navigational speed, and throttle opening.

15

9. An attitude angle control apparatus according to claim 1, wherein the measuring device includes a constant-speed navigation controller measuring and controlling a target engine speed and a valve position of an electronic throttle valve unit of the marine vessel.

20

10. An attitude angle control apparatus according to claim 1, wherein the attitude angle controller includes a trim angle controller controlling a power trim and tilt unit of the marine vessel.

25

11. The attitude angle control apparatus according to claim 1, wherein the statistical model generator calculates estimated values of a plurality of parameters needed to generate the statistical model.

12. The attitude angle control apparatus according to claim 1, wherein the statistical model generator generates the statistical model using one of a least squares method, a weighted least squares method, and a robust estimation method.

5

13. The attitude angle control apparatus according to claim 1, wherein the statistical model generator sets an attitude angle determined based on a plurality of conditions within a numeric range around the attitude angle which provides an optimum value for the statistical model, as a target value of the attitude angle.

10

14. A marine vessel navigation control apparatus which controls navigation of a marine vessel, wherein the marine vessel navigation control apparatus comprises the attitude angle control apparatus according to claim 1.

15

15. A marine vessel navigation control apparatus according to claim 14, further comprising an outboard device including at least one of an electronic throttle valve defining a thrust regulator and a power trim and tilt unit defining the attitude angle controller.

20

16. A marine vessel navigation control apparatus according to claim 14, wherein the measuring device includes a constant-speed navigation controller including a target engine speed calculator that determines a target engine speed of the marine vessel and an electronic-throttle valve position calculator that determines a valve position of an electronic throttle valve to determine total fuel consumption and 25 a speed of the marine vessel for calculating the specific fuel consumption of the marine vessel.

17. A method of controlling an attitude angle of a part of a marine vessel, comprising the steps of:

measuring the attitude angle of the part of the marine vessel and specific fuel consumption of the marine vessel or alternative values relating to the specific fuel

5 consumption of the marine vessel;

generating a statistical model based on data obtained from the measuring step;

and

selecting an optimum attitude angle of the part of the marine vessel based on the statistical model generated in the statistical model generating step.

10

18. A method of controlling an attitude angle of a part of a marine vessel according to claim 17, further comprising the step of controlling the attitude angle of the part of the marine vessel based on the optimum attitude angle.

15

19. A method of controlling an attitude angle of a part of a marine vessel according to claim 17, further comprising the step of calculating a target value of the attitude angle of the part of the marine vessel based on the specific fuel consumption or the alternative values relating to the fuel consumption and based on the statistical model generated in the statistical model generating step.

20

20. A method of controlling an attitude angle of a part of a marine vessel according to claim 19, wherein in the step of calculating the target attitude angle, the attitude angle at which the specific fuel consumption reaches a maximum value is calculated as the target value of the attitude angle based on the statistical model generated in the statistical model generating step.

25

21. A method of controlling an attitude angle of a part of a marine vessel according to claim 19, wherein if a difference between the target value of the attitude angle and a current attitude angle exceeds a limit, the limit is set as the target value of the attitude angle.

5

22. A method of controlling an attitude angle of a part of a marine vessel according to claim 18, wherein the part of the marine vessel of which the attitude angle is controlled is at least one of a hull and a propeller.

10        23. A method of controlling an attitude angle of a part of a marine vessel according to claim 22, wherein an angle of the propeller with respect to the hull is controlled.

15        24. A method of controlling an attitude angle of a part of a marine vessel according to claim 17, wherein the alternative values relating to the specific fuel consumption include at least one of actual total fuel consumption, engine speed, navigational speed, and throttle opening.

20        25. A method of controlling an attitude angle of a part of a marine vessel according to claim 17, further comprising the steps of measuring and controlling a target engine speed and a valve position of an electronic throttle valve unit of the marine vessel.

25        26. A method of controlling an attitude angle of a part of a marine vessel according to claim 18, wherein the attitude angle controlling step includes controlling a power trim and tilt unit of the marine vessel.

27. A method of controlling an attitude angle of a part of a marine vessel according to claim 17, wherein the step of generating a statistical model includes calculating estimated values of a plurality of parameters needed to generate the statistical model.

5

28. A method of controlling an attitude angle of a part of a marine vessel according to claim 17, wherein the step of generating a statistical model includes generating the statistical model using one of a least squares method, a weighted least squares method, and a robust estimation method.

10

29. A method of controlling an attitude angle of a part of a marine vessel according to claim 17, wherein the step of generating a statistical model includes setting an attitude angle determined based on a plurality of conditions within a numeric range around the attitude angle which provides an optimum value for the 15 statistical model, as a target value of the attitude angle.

30. An attitude angle control apparatus control program executable by a computer to control an attitude angle control apparatus which controls an attitude angle of a part of a marine vessel, such that the attitude angle control apparatus 20 performs the steps of claim 17.

31. An attitude angle control apparatus which controls an attitude angle of a part of a marine vessel, comprising:

specific fuel consumption acquisition means for acquiring specific fuel 25 consumption of the marine vessel or alternative values relating to the specific fuel consumption;

evaluated-value calculation means for calculating evaluated values of the attitude angle of the part of the marine vessel based on the specific fuel consumption or the alternative values relating to the specific fuel consumption acquired by the specific fuel consumption acquisition means;

- 5 information acquisition means for acquiring information relating to the evaluated values calculated by the evaluated-value calculation means, the information acquired by the information acquisition means including at least the attitude angle of the part of the marine vessel;
  - information storage means for storing the evaluated values calculated by the
  - 10 evaluated-value calculation means and the information acquired by the information acquisition means;
  - statistical model generating means for generating a statistical model using the specific fuel consumption as an explained variable and the attitude angle of the predetermined part as an explanatory variable based on the evaluated values
  - 15 calculated by the evaluated-value calculation means and information stored in the information storage means;
  - target attitude angle calculation means for calculating a target value of the attitude angle of the part of the marine vessel based on the specific fuel consumption or the alternative values relating to the specific fuel consumption and based on the
  - 20 statistical model generated by the statistical model generating means; and
  - attitude angle control means for controlling the attitude angle of the part of the marine vessel so as to match the target value calculated by the target attitude angle calculation means.
- 25 32. The attitude angle control apparatus according to claim 31, wherein the alternative values relating to the specific fuel consumption include at least one of actual total fuel consumption, engine speed, navigational speed, and throttle opening.

33. The attitude angle control apparatus according to claim 31, wherein each time the evaluated values are calculated by the evaluated-value calculation means and the information acquired by the information acquisition means are newly obtained, the statistical model generating means generates a statistical model based on the newly obtained evaluated values and acquired information.

34. The attitude angle control apparatus according to claim 31, wherein the statistical model generating means calculates estimated values of a plurality of parameters needed to generate the statistical model.

35. The attitude angle control apparatus according to claim 31, wherein the target attitude angle calculation means calculates, based on the statistical model generated by the statistical model generating means, the attitude angle at which the specific fuel consumption reaches a maximum value, as the target value of the attitude angle.

36. The attitude angle control apparatus according to claim 31, wherein if a difference between the target value of the attitude angle calculated by the target attitude angle calculation means and a current attitude angle exceeds a limit, the target attitude angle calculation means sets the limit as the target value of the attitude angle.

37. The attitude angle control apparatus according to claim 31, wherein the statistical model generating means generates the statistical model using one of a least squares method, a weighted least squares method, and a robust estimation method.

38. The attitude angle control apparatus according to claim 31, wherein the statistical model generating means sets an attitude angle determined based on a plurality of conditions within a numeric range around the attitude angle which provides an optimum value for the statistical model, as the target value of the attitude  
5 angle.

39. The attitude angle control apparatus according to claim 31, wherein when acquiring the evaluated values at an initial stage of control, the statistical model generating means adjusts an acquisition range of the evaluated values to  
10 include the attitude angle which provides an optimum value for a statistical model generated in the past by the statistical model generating means.

40. An attitude angle control apparatus according to claim 31, wherein the part of the marine vessel that attitude angle control apparatus controls is at least one  
15 of a hull and a propeller.

41. An attitude angle control apparatus according to claim 31, wherein the specific fuel consumption acquisition means comprises a constant-speed navigation controller controlling a target engine speed and a valve position of an electronic  
20 throttle valve unit of the marine vessel.

42. An attitude angle control apparatus according to claim 31, wherein the attitude angle control means comprises a trim angle controller controlling a power trim and tilt unit of the marine vessel.

43. A marine vessel navigation control apparatus which controls navigation of a marine vessel, wherein the marine vessel navigation control apparatus comprises the attitude angle control apparatus according to claim 31.

5        44. A marine vessel navigation control apparatus according to claim 43, further comprising an outboard device including at least one of an electronic throttle valve defining a thrust regulator and a power trim and tilt unit defining the attitude angle control means.

10      45. A marine vessel navigation control apparatus according to claim 43, wherein the specific fuel consumption acquisition means comprises a constant-speed navigation controller including a target engine speed calculation means for determining a target engine speed of the marine vessel and an electronic-throttle valve position calculation means for determining a valve position of an electronic 15     throttle valve to determine total fuel consumption and a speed of the marine vessel for calculating the specific fuel consumption of the marine vessel.

46. A method for controlling an attitude angle of a part of a marine vessel, comprising the steps of:

20      acquiring specific fuel consumption of the marine vessel or alternative values relating to the specific fuel consumption;  
              calculating evaluated values of the attitude angle of the part of the marine vessel based on the specific fuel consumption or the alternative values relating to the acquired specific fuel consumption;  
25      acquiring information relating to the evaluated values of the attitude angle of the part of the marine vessel, the information acquired including at least the attitude angle of the part of the marine vessel;

generating a statistical model using the specific fuel consumption as an explained variable and the attitude angle of the part of the marine vessel as an explanatory variable based on the evaluated values calculated and the information acquired;

- 5        calculating a target value of the attitude angle of the part of the marine vessel based on the specific fuel consumption or the alternative values relating to the specific fuel consumption and based on the generated statistical model; and controlling the attitude angle of the part of the marine vessel so as to match the calculated target value.

10

47. An attitude angle control apparatus control program executable by a computer to control an attitude angle control apparatus which controls an attitude angle of a part of a marine vessel, such that the attitude angle control apparatus performs the steps of claim 46.

15